

Will surgeries performed at night lead to worse outcomes? Findings from a trauma center in Riyadh

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Abstract

As surgeries are performed around the clock, the time of surgery might have an impact on outcomes. Our aim is to investigate the impact of daytime and nighttime shifts on surgeons and their performance. We believe that such studies are important to enhance the quality of surgeries and their outcomes and help understand the effects of time of the day on surgeons and the surgeries they perform.

A retrospective cohort study was conducted using the database from the King Abdulaziz Medical City trauma center. We selected 330 cases of patients between 2015 and 2018, who underwent a trauma intervention surgery within 24 hours after admission. Patients were aged 15 years and above who underwent 1 or more of the following trauma interventions: neurosurgery, general surgery, plastic surgery, vascular surgery, orthopedics, ophthalmology, and/or otolaryngology. We divided the work hours into 3 shifts: 8 AM to 3:59 PM, 4 PM to 11:59 PM, and midnight to 7:59 AM.

Participants' mean age was 31.4 (standard deviation \pm 13) years. Most surgeries occurred on weekdays (68.4%). Complications were one and a half times more on weekends, with 5 complicated cases on weekends (1.55%) and 3 (0.9%) on weekdays. Half of all surgeries were performed in the morning (152 cases, 53.15%); 73 surgeries (25.5%) were performed in the evening and 61 (21.3%) were performed late at night. Surgeries performed during late-night shifts were marginally better. Complications occurred in 4 out of 152 morning surgeries (2.6%), 2 out of 73 evening surgeries (2.7%), and only 1 out of 61 late-night surgeries (1.6%). The earlier comparison scored a P -value of $>.99$, suggesting that patients in morning and evening surgeries were twice more likely to experience complications than late-night surgeries.

This study may support previous research that there is little difference in outcomes between daytime and nighttime surgeries. The popular belief that rested physicians are better physicians requires further assessment and research.

Abbreviation: SD = sleep deprivation.

Keywords: day shifts, evening shifts, night shifts, sleep deprivation, trauma surgery, weekday surgery, weekend surgery

1. Introduction

Sleep occupies about one-third of the average human lifetime.^[1] It is a natural and essential act of daily human routines; a

physiological need. It has significant influence on the outcome of human mental and motor performance.^[2] Among physicians, sleep—and the lack thereof—has an unclear effect on the outcomes of patients' treatments.^[3] This influence is also reflected on the outcome of a surgeon's job towards the patient, and the proficiency of their mission.^[4]

Prolonged work hours during night shifts and insufficient recovery mainly affect the homeostatic and circadian processes. These may, in turn, influence the physician's performance, with medical errors arising from poor attention or even injuries resulting from sheer exhaustion.^[5] In traumatic cases, unexpected events require full attention and readiness of the surgical team. As such situations are highly stressful, surgeons must act quickly and precisely, and this can only be achieved through alertness and wakefulness.^[6]

Some studies^[7] suggest that there are no significant differences in the mortality rates between daytime and nighttime surgeries. Also, there was no performance weakness for surgeons on the virtual surgery simulator after a night with less sleeping hours.^[8] Other studies concluded that the outcomes were similar for fatigued and rested surgeons.^[9]

Our aim in this study is to investigate and differentiate the impact of daytime and nighttime shifts on surgeons and the outcomes of those surgeries. In addition, we will compare the outcomes of weekday and weekend operations.

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2. Methods

We conducted a retrospective cohort study based on information from the trauma center database of King Abdulaziz Medical City. We selected 330 cases of patients who underwent trauma interventions between January 2015 and August 2018.

This research was reviewed and approved by the institutional review board at the King Abdullah International Medical Research Center (approval number: E-CTS Ref. No. RYD-18-419812-129424). Informed consent was not required in this research since the institutional review board permitted and supervised our retrieval of information from the King Abdulaziz Medical City database without revealing the identity of patients. This work follows the principles of the Helsinki Declaration.

We considered these study variables: age; type of procedure; date, time, and duration of surgery; waiting time from admission to operation; and, whether the surgery was conducted on a weekday or weekend (Friday and Saturday are considered weekends in Saudi Arabia).^[10]

Patients included in the study were aged 15 years and above and underwent a trauma intervention surgery within 24 hours after their admission. Patients underwent one or more of the following trauma operations and interventions: neurosurgery, general surgery, plastic surgery, vascular surgery, orthopedics, ophthalmology, and/or otolaryngology; a field labeled as “other surgeries” was included to cover interventions that do not fit in the above list. Patients who exclusively underwent laparoscopy or thoracoscopy interventions were excluded as the study is focused on outcomes from trauma interventions.

Using analytic distribution, we divided work hours into 3 shifts: 8 AM to 3:59 PM; 4 PM to 11:59 PM; and midnight to 7:59 AM, with each shift consisting 8 hours. We based this on the national working hours where most Saudi Arabian public hospitals and health facilities start at 8 AM.^[11]

Only the first trauma intervention will be included in the study; subsequent trauma interventions will not be counted, if any. We will apply the following variables to the first trauma intervention: date and time of operation, duration of operation, period from admission until the operation is performed, and whether it is conducted on a weekday or weekend.

Variables will be presented as mean, standard deviation, percentage, and number. We used Fisher exact test for the type of surgery and calculations for time of surgery. We also used the Wilcoxon 2-sample test for age, time to surgery, and duration of surgery. SPSS was the chosen statistical program for this research.

We used the post-hoc power calculator for the Wilcoxon 2-sample test. To define the power of Wilcoxon 2-sample test, we used the following: the minimum sample size used in these tests. This was the comparison of “Day of Surgery if Weekend,” which was $221 + 102 = 323$. For the calculations, we used a medium effect size = 0.3, and we define the significance level of our test to be $\alpha = 0.05$ ($P < .05$).

To calculate power of the tests, we used the 2-sample *t*-test power calculation from the package “pwr” of the R statistical and computing environment. The structure of the test was: $d = 0.3$, $N = 330$, $sig.level = 0.05$, $power = ?$, where d is effect size; N is total number of observations; $sig.level$ is significance level (with Type I error probability), and $power$ is power of test (1 minus Type II error probability), the requested power of our test. These were the test results: $d = 0.3$, $N = 330$, $sig.level = 0.05$, $alternative = 2$ -sided, and $power = 0.9704854$. The number that we sought is the last number in this test, or $power = 0.9704854$. This number

indicates that, with a minimum sample size of 330, the power of our test is 97%. This means that by using the Wilcoxon 2-sample test, we have 97% chance of detecting difference.

We further created a graph to visualize this power with respect to our sample size (Fig. 1).

We discuss here the post-hoc power calculation for Fisher exact test. To define the power of Fisher exact test, we used the following: the minimum sample size used in these tests. This was the comparison of “Time of Surgery,” which was $279 + 7 = 286$. The proportions were $p_1 = 0.9755245$, $p_2 = 0.02447552$; we define the significance level of our test to be $\alpha = 0.05$ ($P < .05$), and we used 1000 simulations for the calculation, $nsim = 1000$.

To calculate the power of the tests, we used the “Power of Fisher Exact Test for Comparing Proportions” from the package “statmod” of the R statistical and computing environment. The structure of the test was: $n_1 = 279$, $n_2 = 7$, $p_1 = 0.9755245$, $p_2 = 0.02447552$, $\alpha = 0.05$, $nsim = 1000$. These were the test results: $power = 1$, which is the number that we sought in this test. This number indicates that, with a minimum sample size of 286, the power of our test is 100%. This means that the Fisher exact test we conducted has 100% chance of detecting difference.

In summary, to define the power of the statistical tests (Wilcoxon 2-sample test and Fisher exact test), we conducted post-hoc power tests. For the Wilcoxon 2-sample test, for effect size $d = 0.3$ and sample size $N = 330$, we calculated $power = 0.9704854$, meaning that the Wilcoxon 2-sample test we conducted has 97% chance of detecting difference. For the Fisher exact test, for sample size 286 with $n_1 = 279$, $n_2 = 7$, $p_1 = 0.9755245$, $p_2 = 0.02447552$, we calculated $power = 1$, meaning that the Fisher Exact Test we conducted has 100% chance of detecting difference.

3. Results

Eight cases out of the 330 cases included in this study had complications. The mean age was 31.4 years with a standard deviation of 13 years. Most of the cases took place on weekdays (68.4%). Cases with complications occurred one and a half times more on weekends than on weekdays (Fig. 2 and Table 1); there were 5 cases with complications on weekends (1.55%) compared to 3 (0.9%) on weekdays. Half of all surgeries were performed in the morning (152 cases or 53.15%); 73 cases or 25.5% were performed in the evening, and 61 cases or 21.3% were performed in the late night. Complications occurred mostly in the morning (4 cases or 1.4%); there were 2 cases with complications in the evening (0.7%) and only 1 case with complications in the late night (0.35%) (Fig. 3 and Table 1). Majority of the trauma cases were performed by the general surgery team (137 cases or 41.5%); the neurosurgery team had 73 surgeries (22.1%) and the orthopedic team had 50 surgeries (15.15%) (Fig. 4 and Table 1). Seven of the 8 complications happened with the general surgery team, and 1 complication happened with the neurosurgery team. The mean time to surgery was 4.9 hours with a standard deviation of 1.7 hours, and the mean duration of surgery was 3.5 hours with a standard deviation of 1.7 hours. By comparing the time of surgery, we will find that the mean time of surgery for the complicated cases is 4.6 ± 2.9 hours compared to 4.9 ± 4.6 hours for the noncomplicated surgeries. Also, when comparing the duration of surgery, it is 3.6 ± 3 hours for the complicated surgeries compared to 3.5 ± 1.7 hours for the noncomplicated surgeries (Table 1).

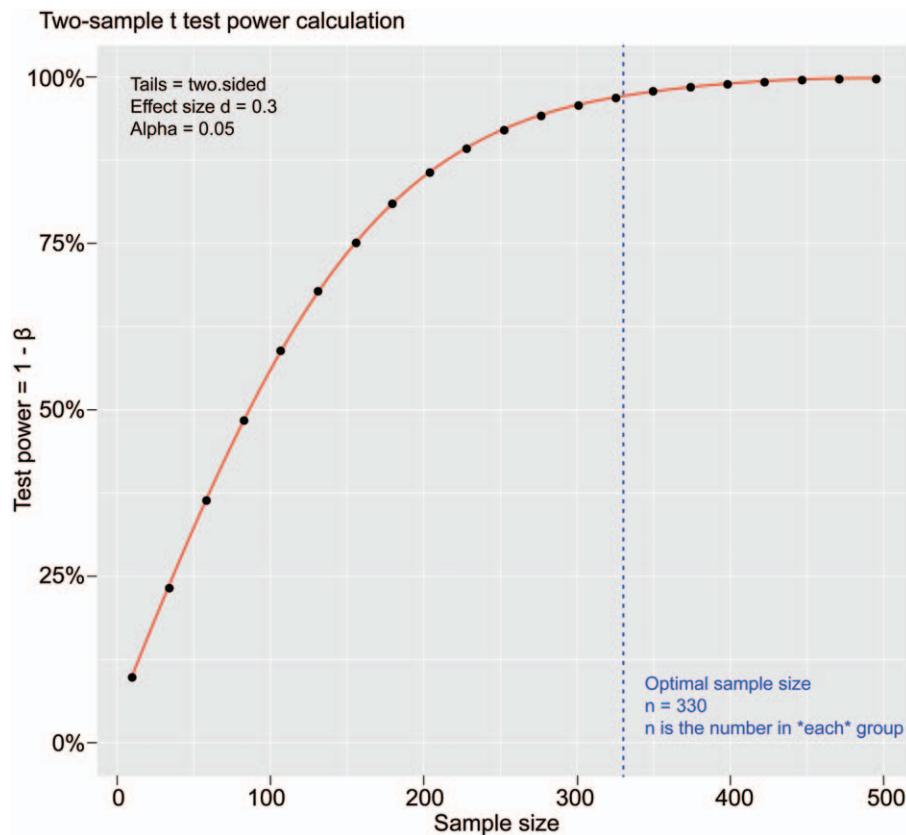


Figure 1. Power of the Wilcoxon 2-sample test with respect to sample size.

4. Discussion

The data collected show that, out of the overall number of operations, not many cases have complications. Nonetheless, there is still strong evidence that time of surgery has no significant impact on outcomes.

Weekday surgeries with complications were 3 out of 221 (1.35%). On the other hand, weekend surgeries with complications were 5 out of 102 (4.9%). There were almost 3 and a half times more cases with complications on weekends. Specifically,

accidents tend to be more severe and frequent on the weekends, as suggested by the report of Barrimah et al^[12] that traffic accidents in the Al Qassim region of Saudi Arabia were much higher on weekends because that is when unlawful car racing as a leisure activity by adolescents tends to occur. A Japanese study has reported higher mortality for surgeries on weekends than weekdays.^[13]

Regarding time of day, the data in Table 1 shows that surgeries performed during late-night shifts had slightly better results.

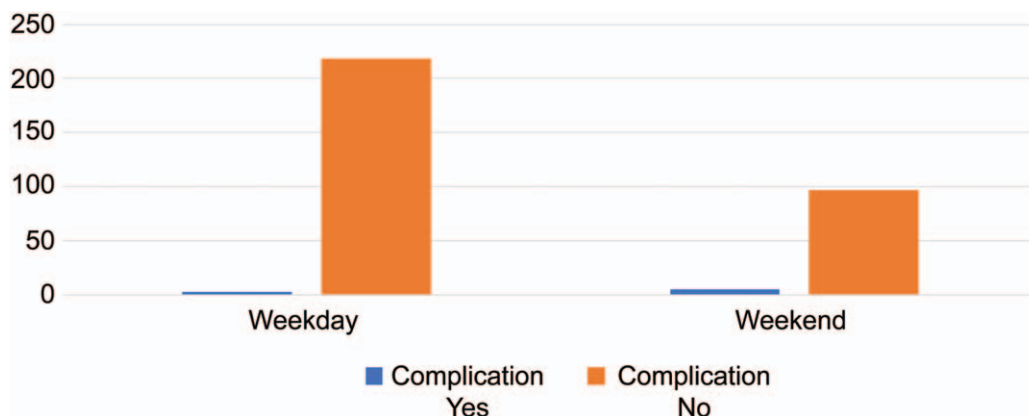


Figure 2. Day of surgery.

Table 1
Distribution of cases according to study variables.

		Total	Complication Yes	Complication No	P-value
Age n (mean ± SD)		327 (31.403 ± 13.002)	8 (31.000 ± 11.110)	319 (31.285 ± 12.843)	.88
Day of surgery if Weekend n (%)	No	221 (68.4%)	3 (0.9%)	218 (67.5%)	-
	Yes	102 (31.6%)	5 (1.55%)	97 (30.0%)	
Time of surgery n (%)	Morning 8 AM–4 PM	152 (53.15%)	4 (1.4%)	148 (51.75%)	.99
	Evening 4 PM–12 AM	73 (25.5%)	2 (0.7%)	71 (24.8%)	
	Late night 12 AM–8 AM	61 (21.3%)	1 (0.35%)	60 (21.0%)	
	Total	286	7 (2.45%)	279 (97.55%)	
Type of surgery n (%)	Orthopedic Surgery	50 (15.15%)	0 (0.0%)	50 (15.15%)	.33
	Neurosurgery	73 (22.1%)	1 (0.3%)	72 (21.8%)	
	General Surgery	137 (41.5%)	7 (2.1%)	130 (39.4%)	
	Plastic surgery	54 (16.4%)	0 (0.0%)	54 (16.4%)	
	Vascular Surgery	9 (2.7%)	0 (0.0%)	9 (2.7%)	
	Ophthalmic Surgery	2 (0.6%)	0 (0.0%)	2 (0.6%)	
	Other surgery	5 (1.5%)	0 (0.0%)	5 (1.5%)	
	Total	330	8 (2.4%)	322 (97.6%)	
	Time to surgery n (mean ± SD)		327 (4.954 ± 4.682)	8 (4.643 ± 2.926)	
Duration of surgery n (mean ± SD)		327 (3.520 ± 1.777)	8 (3.667 ± 3.077)	319 (3.518 ± 1.749)	.75

SD = standard deviation.

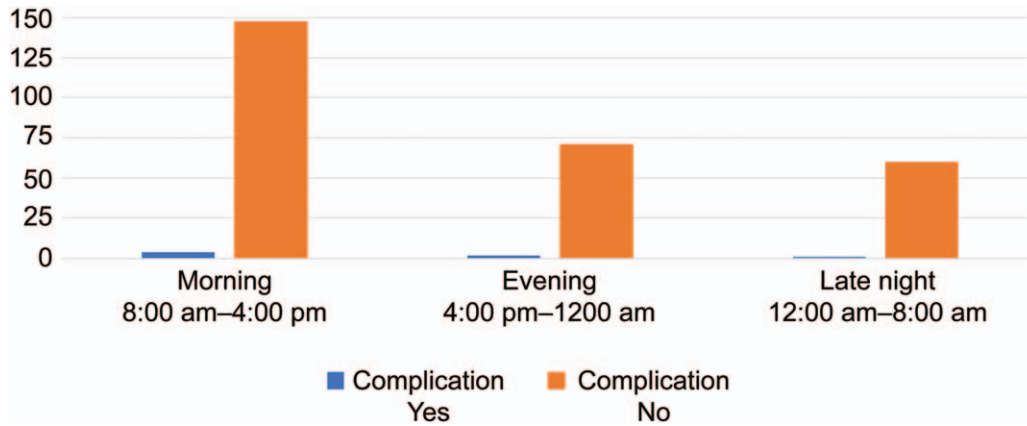


Figure 3. Time of surgery.

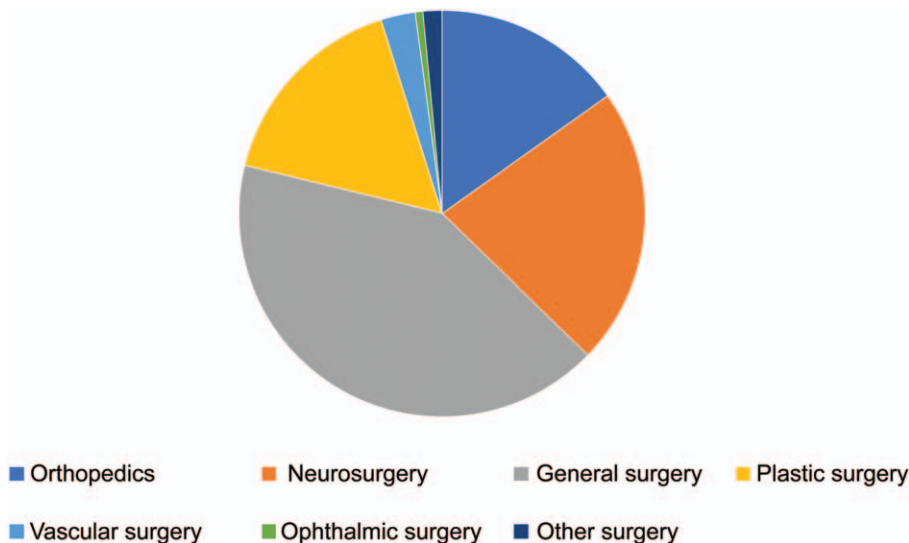


Figure 4. Type of surgery.

Morning surgeries with complications were 4 out of 152 (2.6%); evening surgeries with complications were 2 out of 73 (2.7%), and there was only 1 late-night surgery with complications out of 61 (1.6%). This suggests that morning and evening surgeries were twice as likely as late-night surgeries to be subject to complications.

Most of the complications happened during general surgeries (Table 1), and most of the complicated surgeries recorded were exploratory laparotomies. The ages of the patients who had complications ranged from 19 to 37 years (mean age 28 years). Four of these 7 surgeries were performed during the weekend. The complications recorded were hypovolemic shock, postoperative bleeding, coagulopathy, pneumonia, cardiac arrest, disseminated intravascular coagulation, and death.

There was no strong evidence to indicate the main variable underlying the complications. From a wider perspective, culture plays a significant role. Some argue that a large portion of the community goes to bed late at night as a habit, for reasons that might include but are not limited to weather—since it can be unbearably hot during the daytime. Such factors may affect the duration and quality of one's sleep and consequently, compromise performance and outcomes.

Prior studies have correlated sleep quality and performance. The main hypothesis to explain compromised outcomes was practitioners' lack of sleep.^[14–16] Prior studies have correlated sleep quality and performance. A cross-sectional survey^[17] conducted in Jeddah, Saudi Arabia, propounds an association between poor sleep patterns and low grades. In a random sample of 1035 high school students, 37% of the students showed predictors of excessive daytime sleepiness such as napping, stress, and caffeine use; the study also states that poor sleep patterns were more common in males than in females. Although some behaviors, like weekend catch-up sleep, may mitigate the effect for adults who suffer from lack of sleeping hours throughout the weekdays, sleep debt is known to have harmful effects on overall health and quality of life.^[18]

Yaghoubian et al^[19] assumed that no data has so far been available regarding surgeon trainees' outcomes from working more than 16 hours a day in an 80-hour work week. The medical institute where that study was conducted recommended allowing on-call residents 5 hours of rest time in duty hours after every 16 hours of work. The study suggests; however, that the 5 hours of rest would likely make no difference: night trauma surgeries performed by residents after shifts longer than 16 hours had similar outcomes to daytime surgeries.

In 2015, Zafar et al concluded in their study^[17] that there are no significant differences in mortalities between nighttime and daytime surgeries, based on the collected data, which may vary depending on the level of success of the trauma program. Additionally, studies^[20,21] have shown that cholecystectomy, which is performed in about 600,000 cases annually^[22] as one of most common abdominal surgeries in the United States, has similar complication rates at any time of day and may be safely performed during the day or the night. Moreover, supracondylar humeral fractures, the most common elbow fractures in the pediatric group, account for 60.3 to 71.8 per 100,000 children annually.^[23] For these fractures, no statistically significant differences have been found among mean operative, surgical, and fluoroscopy time; however, nighttime surgery and fluoroscopy for type III supracondylar humeral fractures were longer compared to day and evening surgeries.^[24]

An interesting paper^[25] described a simulation where 8 participants (an attending spine surgeon and 7 orthopedic residents) performed a 1-level lumbar laminectomy and instrumented fusion on a cadaver. Indirect calorimetry was used to measure their oxygen consumption, and showed a modest but significant increase in their energy expenditure over resting. Unexpectedly, substrate utilization and carbohydrates usage during the simulation surgery were higher and earlier than expected. Such unexpectedly high utilization could be attributed to the mental stress of the task.

For patients with traumatic spinal cord injury, where timing might be controversial, a study^[26] reported a beneficial effect of early decompressive surgical intervention. On the contrary, where emergency resection is a risk factor for mortality and morbidity in glioma patients, a study^[27] of 477 nonemergency surgeries and 30 emergency surgeries found that the start time of the operation does not predict postoperative mortality and morbidity, regardless of emergency or nonemergency glioma resection.

One might argue that for crucial surgeries like acute aortic dissection, where the mortality rate is as high as 1% to 2% per hour in the first 24 hours^[28] and 20% of patients die before reaching the hospital,^[29] or for different types of transplant surgeries, the consequences might be different. However, some papers^[30,31] have concluded that the time of day of the surgery has no significant effect in acute aortic dissection type A surgery. On the contrary, higher mortality was found in the longer time interval from hospital arrival to computed tomography scanning in blunt traumatic aortic injury,^[32] which is the second leading cause of death for trauma patients.^[33] In addition, in a paper^[34] that surveyed 27,305 cardiac surgery patients between 2010 and 2017 to compare morning and afternoon cardiac surgeries (procedures that included coronary artery bypass graft with internal mammary, or thoracic artery and vein or radial artery bypass) in regard to surgical site infections and mortality, the conclusion was that current evidence is not enough to favor afternoon cardiac surgeries, and that increased rates of morning myocardial infarction were not associated with an impact on the 1-year deep surgical site infections or mortality rate. Furthermore, there are a number of studies^[35–37] of different transplant surgical procedures that have concluded that there is no higher risk, no poorer outcomes, and no adverse complications during nighttime surgeries compared to daytime.

A study has further explained that there is no performance impairment for surgeons on the virtual surgery simulator after a night with fewer sleep hours. A standardized cognitive test was run on surgery residents after a night with less sleep, and nothing significant was found.^[8] This finding suggests that there is no significant impact of less sleep on physicians' cognition and performance. Other factors may be involved; it has been noted that night shift nurses have a high risk of sleep disturbance,^[38] and nighttime prehospital deployments of prehospital emergency physicians have been identified as a high risk for medication errors.^[39] Another factor is depression and anxiety among physicians, where significantly low risks of depression and anxiety were noted among internal medicine and surgery physicians.^[40] However, it has been noted that long working hours could have a negative effect on physicians, that is, they could cause health issues^[41] and they lower the empathy of health professionals toward their patients.^[42]

In another study, approximately 600 cases have roughly similar results, in regard to mortality and morbidity outcomes of

the surgeries that been performed by fatigued and non-fatigued surgeons. However, the nub of the argument, is that rested surgeons who were more likely to perform on older or female patients, they concluded that the outcomes were similar for fatigued and rested surgeons,^[9] which we think brought the same debate back to surface.

Further research in this area appears to validate the previous findings. Data were collected from the national trauma bank comprising about 16,000 exploratory laparotomies conducted between midnight and 6 AM, and about 15,000 conducted between 7 AM and 5 PM. This research concluded that there are no significant differences in outcome and mortality among patients, whether the surgery was carried out in the morning, afternoon, or even late at night.^[3]

This study may support many previous studies that there is not much difference in the outcome of the surgical operations performed between morning and late time. Yet, the opposite belief that rested physicians are better than fatigued ones continues. As Alhola and Polo-Kantola concluded: “Total sleep deprivation (SD) impairs a range of other cognitive functions as well. In partial SD, a more thorough evaluation of higher cognitive functions is needed.”^[43]

Based on the above evidence, it can be suggested that late-night surgical operations might have outcomes similar to or better than those of daytime surgeries. The following studies may suggest the opposite. In a retrospective cohort study, using data from level 1 trauma center registry,^[44] admissions were divided into early shifts (6 PM to midnight) and late shifts (midnight to 7 AM). Staff trauma surgeons were categorized as more experienced and second-year trauma fellows as less experienced. Results of the study favored the less-experienced fellows providing nighttime initial trauma care; in other words, the fellows had better nighttime outcomes. Research staff listed the following possible factors for this conclusion: age-related effect of sleep loss, difference in responsibilities between staff and fellows in the daytime, and supervision of nighttime fellows. Moreover, a nationwide study based on the Japan Trauma Data Bank^[45] from 2004 to 2015 divided the day into 2 shifts (daytime, 9 AM to 4:59 PM, and nighttime, 5 PM to 8:59 AM) and found a significant daytime decrease in deaths among emergency trauma patients, both in the emergency room and at hospital discharge; there was no association between weekday/weekend and outcomes. In addition, a systematic review^[46] of 40 observational studies that included about 3 million patients concluded that postoperative risk of mortality is associated more with surgery performed at night/after-hours than surgery performed during the day. Another research study^[47] found that afternoon surgeries showed rapid recovery to baseline cortisol compared to morning surgeries, and that afternoon surgery should be considered in patients with inflammation or postoperative delayed wound healing.

There were some limitations to this study. First, there were limited numbers of complications due to the limited number of surgeries, and limited trauma cases that were being transferred to the trauma center where this study was conducted. Second, we were unable to establish and ascertain a clear causal relationship between lack of sleep or SD and complications. Lastly, we were unable to generalize the results to other types of surgeries and different centers. This can be the starting point for further research.

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